Balanced Ventilation: Understanding the Options

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Description

As homes continue to become more efficient, specifically related to envelope airtightness, a greater emphasis has been placed on indoor air quality (IAQ). Mechanical ventilation systems are key to ensuring proper IAQ in new homes. For new construction, builders often debate the merits of readily available systems and strategies. This session will focus on balanced ventilation systems, specifically heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs). The focus of this session will include the common benefits to builders and occupants in terms of performance and IAQ as well as the challenges of system complexity and cost.

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Learning Objectives

1. Understand the code provisions related to mechanical ventilation in the 2018 International Residential Code and how they impact the selection of ventilation strategies.
2. Examine currently available equipment and system options that builders may consider when providing homeowners with a well-designed strategy.
3. Discuss the benefits and challenges of common systems, including installation, cost, complexity, and performance.
4. Identify opportunities for builders to utilize ventilation strategies and systems as selling points to potential clients.

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Why is Whole-House Mechanical Ventilation Needed?

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The Need for Ventilation

- Modern energy codes require tighter enclosures

  BUT
- Reducing natural infiltration limits the amount of fresh air available for occupants

- "Build tight - ventilate right"
  - Perera, E., and L. Parkins. "Build tight–ventilate right." Building Services, CIBSE June (1992).

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2018 IRC N1102.4.1.2 (R402.4.1.2) Testing

- The building or dwelling unit shall be tested and verified as having an air leakage rate of not exceeding five air changes per hour in Climate Zones 1 and 2, and three air changes per hour in Climate Zones 3 through 8. Testing shall be conducted in accordance with RESNET/ICC 380, ASTM E779 or ASTM E1827 and reported at a pressure of 0.2 inch w.g. (50 Pascals). Where required by the building official, testing shall be conducted by an approved third party. A written report of the results of the test shall be signed by the party conducting the test and provided to the building official. Testing shall be performed at any time after creation of all penetrations of the building thermal envelope.

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Blower Door Concept

- Depressurize the home to an exaggerated pressure difference to quantify air infiltration and compare with established benchmarks
- ACH_{50} = Air Changes per Hour at pressure difference of 50 Pa
  - Current limit in Pennsylvania is 3 ACH_{50}
  - 50 Pa simulates roughly a 20 mph wind on all sides of the home

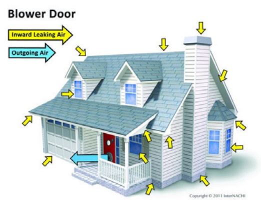

Image Source: https://www.naeci.com/blower-door-testing

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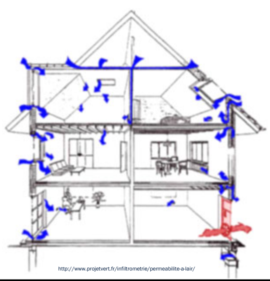
Airtightness Requirement: 5 ACH50



http://www.projetvert.fr/infiltrometrie/permeabilite-a-lair/

- Measured in Air Changes Per Hour at 50 Pascals (ACH50 / ACH_{50})
  - 50 pascals – equivalent to 20 MPH wind on the house

Value we need (Air Changes Per Hour @ 50 Pascals)

Value from the blower door pressure gauge (Cubic Feet Per Minute @ 50 Pascals)

Constant (60 minutes per hour)

$$ACH_{50} = \frac{CFM_{50} \times 60}{V} < 3$$

Volume of the House (Cubic Feet)

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2018 Ventilation Requirements

- R303.4 Mechanical Ventilation
  - Where the air infiltration rate of a dwelling unit is 5 air changes per hour or less where tested with a blower door at a pressure of 0.2 inch w.c (50 Pa) in accordance with Section N1102.4.1.2, the dwelling unit shall be provided with whole-house mechanical ventilation in accordance with Section M1505.4.

Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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M1505.4: Whole-House Mechanical Ventilation System

- **M1505.4.1 System design.** The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.

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Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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M1505.4: Whole-House Mechanical Ventilation System

- **M1505.4.2 System controls.** The whole-house mechanical ventilation system shall be provided with controls that enable manual override.

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Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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M1505.4: Whole-House Mechanical Ventilation System

- **M1505.4.3 Mechanical ventilation rate.** The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate **as determined in accordance with Table M1505.4.3(1) or Equation 15-1.**
  - Equation 15-1: *Ventilation rate in cubic feet per minute = (0.01 x total square foot area of house) + [7.5 x (number of bedrooms + 1)]*

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Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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M1505.4: Whole-House Mechanical Ventilation System

- **Exception:** The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25-percent of each 4-hour segment and the ventilation rate prescribed in Table M1505.4.3(1) is multiplied by the factor determined in accordance with Table M1505.4.3(2).

20 *Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.*

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2018 IRC Table M1505.4.3 (1) & (2)

TABLE M1505.4.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 - 1	2 - 3	4 - 5	6 - 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

TABLE M1505.4.3(2)
INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS

RUN-TIME PERCENTAGE INEACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor	4	3	2	1.5	1.3	1.0

21 *Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.*

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Mechanical Ventilation Examples

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Example #1

Small Home
- Size: 1,350 SF
- Bedrooms: 3
- Bathrooms: 1.5

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Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

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2018 IRC Table M1505.4.3 (1)

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CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

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3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
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> 7,500	105	120	135	150	165

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Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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Example #2

Medium Home
- Size: 2,300 SF
- Bedrooms: 4
- Bathrooms: 2.5

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Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

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2018 IRC Table M1505.4.3 (1)

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CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

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6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

26 Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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Example #3

Large Home
- Size: 5,300 SF
- Bedrooms: 6
- Bathrooms: 4

27 Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

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2018 IRC Table M1505.4.3 (1)

TABLE M1505.4.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

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3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
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28 Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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Whole-House Mechanical Ventilation Options

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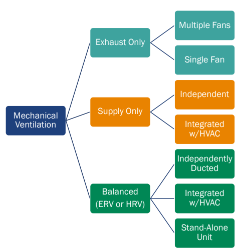
3 Design Solutions For Whole-House Mechanical Ventilation

- Exhaust-only
- Supply-only
- Balanced system



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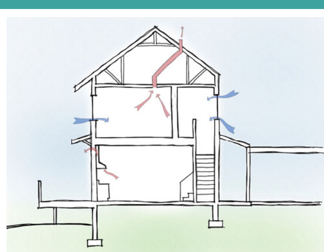
Exhaust-Only Ventilation



Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

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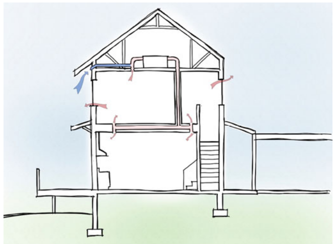
Supply-Only Ventilation



Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

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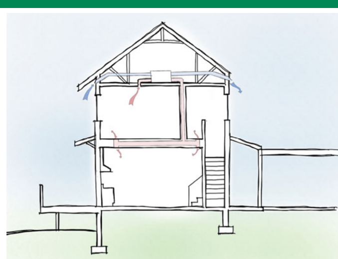
Balanced System Option



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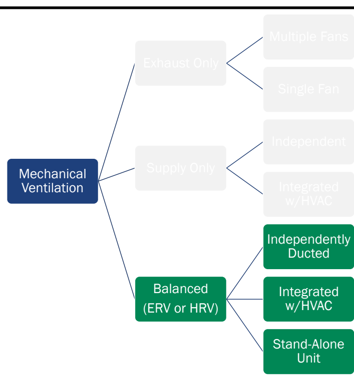

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How a Balanced System Works

- Balanced ventilation systems combine supply and exhaust systems
- Most systems have built-in heat recovery capabilities so that heat is transferred between the exhaust air and the supply air
- Some systems are also capable of transferring moisture

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Balanced Pros/Cons

PROS	CONS
• A balanced system transfers heat which increases comfort and decreases the load on the HVAC system • A balanced system maintains a neutral pressure difference which in turn reduces the strain on the building thermal envelope	• Highest installed cost option for whole-house mechanical ventilation • Requires regular maintenance and filter changes

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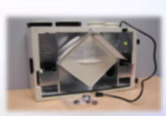
Balanced Air Flow Options

ERV aka:
- Energy Recovery Ventilator
- Heat Exchanger
- Sensible and Latent Recovery
- Energy Wheel
- Static Plate Core
- Enthalpic Plate

HRV aka:
- Heat Recovery Ventilator
- Sensible Recovery
- Heat Exchanger



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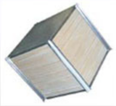
Common Energy Recovery Media / Packages

HRV: Heat Recovery Ventilator
Core material: Aluminum or Plastic
Sensible only recovery
20-30% total effectiveness
Manufacturers: Fantech, Lifebreath, Venmar

ERV: Enthalpy Wheel
Wheel material:
- Aluminum
- Synthetic Fiber
- Polymer

Sensible and Latent recovery
70-80% total effectiveness
Manufacturers: Greenheck, SEMCO



ERV: Enthalpy Core
Core material: Hydroscopic Resin
Sensible and Latent recovery
60-65% total effectiveness
Manufacturer: RenewAire, S&P, Mitsubishi

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HRV vs ERV Does it Matter?

- HRV's
  - Transfer temperature differential - sensible heat
  - Aluminum or plastic cores
  - Require condensate pan and drain – must be considered during installation
  - Require defrost cycle
  - Virtually no latent exchange – poor summer performance
- ERV's
  - Transfer both sensible & latent (humidity) heat
  - Desiccant wheels or enthalpic plate cores
  - No condensate pans or drains
  - No defrost cycle required
  - Can be installed in any configuration
  - Effective energy exchange in all seasons

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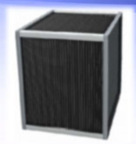
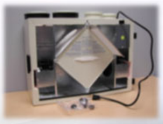
HRV: Sensible Core - Review

- Numerous Media Manufacturers
  - Packaged HRV Equipment
- Common Transfer material
  - Aluminum
  - Polypropylene
- Performance
  - The return and supply airstreams pass within air passages perpendicular to each through the plate material
  - Liquid water is a common byproduct
- Critical Media Components
  - End pans and frame
  - Defrost
  - Drain pan
  - Associated plumbing





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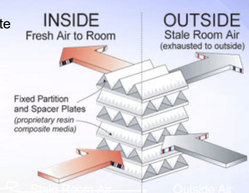
ERV: Enthalpy Core - Review

- Transfer Performance
  - Air passages perpendicular to each airstream though the plate material
  - Sensible via conduction
  - Latent via diffusion
- Straight Air Passages
  - Laminar Flow
- Typical Velocity
  - 250 - 500 ft./ min.
- Static pressure loss
  - 0.6 – 1.2 inch



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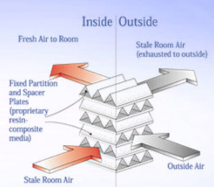
How Does Energy Exchange Work?

- *Static-Plate Core* allows exhaust and outside air streams to cross paths in the core, *transferring both heat and moisture* in the process.



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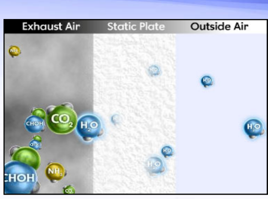
How does the Energy Exchange work?



Water molecules (vapor) and heat permeate the media

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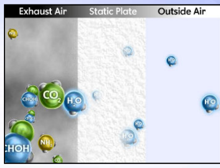
How does the Energy Exchange work?

RenewAire ERV are AHRI Certified for 0% Cross Leakage

- Allows H2O molecules (2.8 angstrom) to efficiently pass through core membrane
- SO**2**, NOx, CO2, etc are exhausted out of building
- No clogging when laminar flow is maintained. (Correct Size)



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Fundamentals of Energy Recovery Ventilation

- Summer: Pre-cooling /drying of hot & humid incoming air
- Winter: Pre-heating/humidifying of cold & dry incoming air
- Transfers upwards of 55 - 75% of the energy in the exhaust air stream to fresh air stream

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Performance Certification

- HVI Certified – Home Ventilating Institute
- AHRI Certified – Air Conditioning & Refrigeration Institute (Standard 1060)
- UL Listed – Underwriters Laboratories

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Integrated System: Simplified

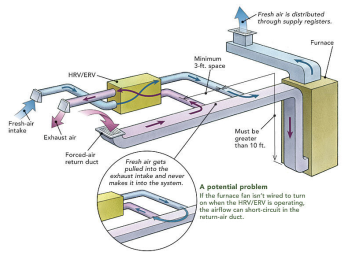

Image Source: https://www.finehomebuilding.com/2014/11/05/ducting-hrvs-and-ervs

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Integrated System: Exhaust-Ducted

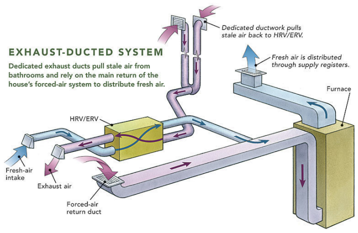

Image Source: https://www.finehomebuilding.com/2014/11/05/ducting-hrvs-and-ervs

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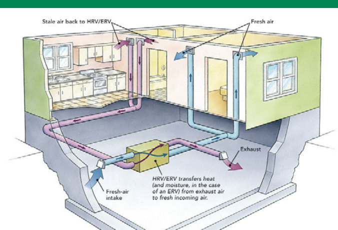
Independently Ducted System



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RESIDENTIAL VENTILATION

EV Series available in 6 models from 50 to 300 CFM
- EV90/90P/130/200/240/300
- All feature AC fan motors
- Various controls and accessories available

EV Premium
- EV Small/Medium/Large (30-240 CFM)
- All feature EC fan motors
- Merv 13 filter optional
- Various controls and accessories available
- Hard wired version

SL75 (arriving mid-June 2022)
- One size (30-130 CFM)
- Feature EC fan motors
- Merv 13 filter optional
- Various controls and accessories available

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Overview

- Ideal for single and multi-family structures, as well as light-commercial buildings
- Multiple Models
- Heat and humidity transfer using one static plate G5 core
- 2 High-Efficiency EC motor impellers on (EV Premium and SL75)
- Boost-mode capabilities to further enhance IAQ (EV Premium and SL75)
- Dial-A-Flow controller that allows setting airflow for maximizing comfort
- Indoor Only
- SL75 is replacement for discontinued SL70

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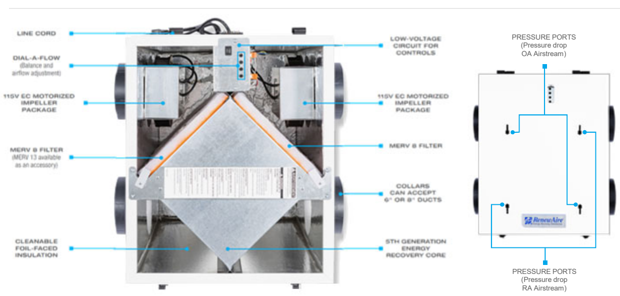
Visual Overview (EV Premium)



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Feature Matrix

EV Premium	S	M	L
Air Flow Range	30-140 CFM	30-225 CFM	30-280 CFM
Power Supply	Line Cord		
Fan/Motor	ECM Impellers w/ Independent Variable Speed		
Boost Mode	Yes		
Length	22 1/2"	22 1/2"	22 1/2"
Width	9 1/2"	12 5/8"	23 5/8"
Height	23 3/4"	23 3/4"	23 3/4"
Weight	32 lbs.	36 lbs.	52 lbs.
Mounting	Ceiling Bracket / Wall Bracket		
Filter	MERV 8 (standard) / MERV 13 (accessory for supply outside air only)		
Warranty Core / Unit	10 years / 5 years		
Fan Efficiency	1.82 CFM/Watt at 51 CFM (0.2" ESP)	2.10 CFM/Watt at 101 CFM (0.2" ESP)	2.70 CFM/Watt at 121 CFM (0.2" ESP)
Certifications	HVI & ETL		

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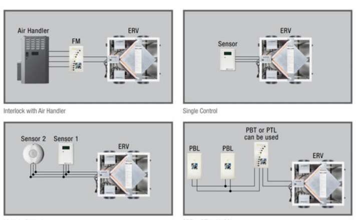
Controls



Accessories
- Percentage Timer (PTL)
- PTL w/ Furnace Interlock (FM)
- Push Button Point of Use Timer (PBL)
- Push Button Boost Timer (PBT)
- CO2 Sensor (Duct/Wall Mount)
- Occupancy Sensor (Duct/Wall Mount)
- IAQ Sensor (Duct/Wall Mount)
- Digital Time Clock (Wall Mount/Exterior Enclosure)

 Note: Images are of EV Premium M, SL75 has the same controls 55

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Accessories

Heaters
- RH Series Electric Duct Heaters (1 to 4 kW)*
- Indirect Gas-Fired Duct Furnaces are not available

Filters
- MERV 13 Available for OA Airstream

Dampers
- Automatic Balancing Valve (4, 5, 6")
- Backdraft

Mounting
- Wall-Bracket Kit

Louvered Wall Vents
- 6" White or Brown

 * Actual wattage limited by unit CFM 56

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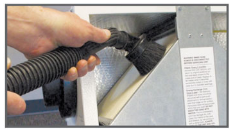
Maintenance

- Filters should be checked and replaced as needed
- Once a year, vacuum the four core faces using a soft brush end tool
- Core does not need to be washed as particulates do not accumulate in the core



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Performance Examples

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EV Premium M @ 75 cfm

Unit Accessories and Service Parts

No accessories for this unit

	SUMMER			WINTER		
	Outdoor Air	Return Air	Fresh Air	Outdoor Air	Return Air	Fresh Air
Standard Flow Rate **S FM**	75	75	75	75	75	75
Dry Bulb °F	93.4	75.0	78.9	13.8	70.0	58.1
Wet Bulb °F	75.1	62.6	67.7	10.2	51.5	43.6
Enthalpy >H? **BTU**	38.4	28.1	32.0	3.9	21.0	16.8
Moisture Ratio >MR? **rains**	101.7	64.7	83.6	3.7	27.1	18.8
Fresh Air - EXternal Static Pressure **in ! !**	0.50			0.50		
EXhaust Air - EXternal Static Pressure **in ! !**	0.50			0.50		
Sensible effectiveness %	78.8			78.8		
Total effectiveness %	62.0			75.6		
Load savings ratio %	62.0			75.6		
Moisture removed **rains**	18.1			-15.1		
	Sen	Lat	Tot	Sen	Lat	Tot
Original load **BTUH [Tons]**	1490 [0.1]	1993 [0.2]	3484 [0.3]	4552	1235	5788
Load with RenewAire **BTUH [Tons]**	317 [0.0]	1007 [0.1]	1324 [0.1]	967	444	1411
Total energy saved **BTUH [Tons]**	1174 [0.1]	987 [0.1]	2160 [0.2]	3585	791	4376

Note: Sensible cooling design conditions were used for the summer performance results.

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EV Premium M @ 120 cfm

Unit Accessories and Service Parts

No accessories for this unit

	SUMMER			WINTER		
	Outdoor Air	Return Air	Fresh Air	Outdoor Air	Return Air	Fresh Air
Standard Flow Rate **S FM**	120	120	120	120	120	120
Dry Bulb °F	93.4	75.0	80.0	13.8	70.0	54.7
Wet Bulb °F	75.1	62.6	68.8	10.2	51.5	41.1
Enthalpy >H? **BTU**	38.4	28.1	32.9	3.9	21.0	15.7
Moisture Ratio >MR? **rains**	101.7	64.7	87.5	3.7	27.1	16.4
Fresh Air - EXternal Static Pressure **in ! !**		0.50			0.50	
EXhaust Air - EXternal Static Pressure **in ! !**		0.50			0.50	
Sensible effectiveness **%**		72.8			72.8	
Total effectiveness **%**		53.4			68.8	
Load savings ratio **%**		53.4			68.8	
Moisture removed **rains**		14.2			-12.7	
	Sen	**Lat**	**Tot**	**Sen**	**Lat**	**Tot**
Original load **BTUH [Tons]**	2385 [0.2]	3190 [0.3]	5574 [0.5]	7284	1977	9260
Load with RenewAire **BTUH [Tons]**	649 [0.1]	1946 [0.2]	2595 [0.2]	1982	907	2889
Total energy saved **BTUH [Tons]**	1736 [0.1]	1243 [0.1]	2979 [0.2]	5301	1069	6371

Note: Sensible cooling design conditions were used for the summer performance results.

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Summary

- Mechanical ventilation is required
- There are several different choices available to meet the requirement
- Balanced ventilation provides the best option (?)
- HRV/ERV provides an actual payback on the cost
- ERV's are a better choice where air conditioning and humidity are concerns

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